WRIGHT FLYER ON-LINE
Up, Up, and Away-Analyzing Coefficient of Lift Data
Student Page

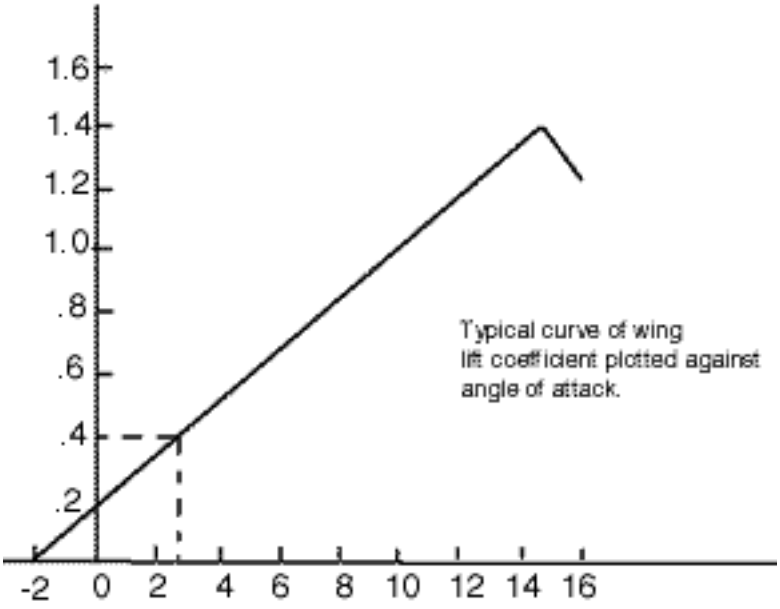
MATERIALS NEEDED

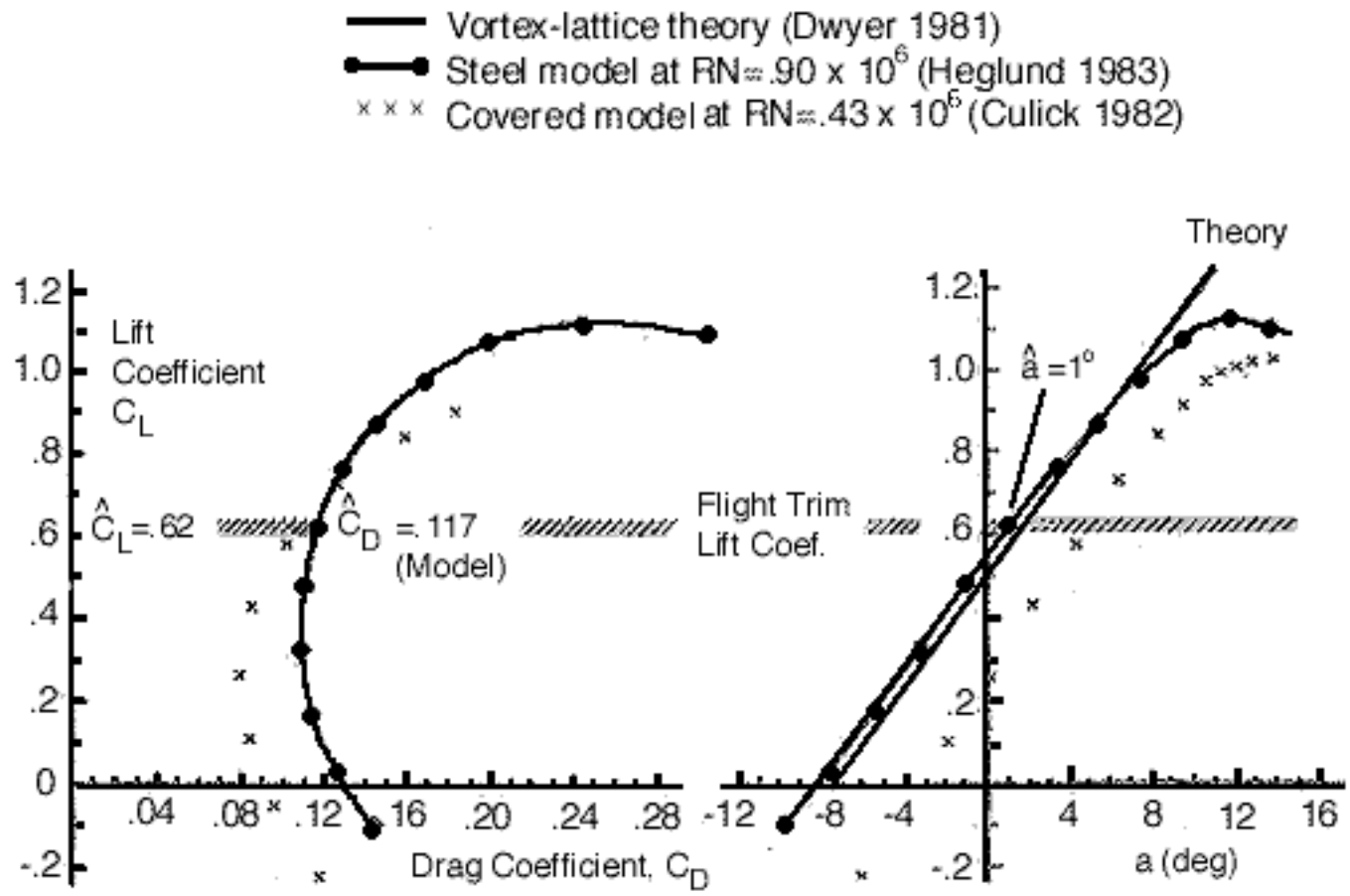
Graph Paper
Calculator
Graphing calculator (optional)
Graph link and computer (optional)

Lift is the name given to the force that enables an airplane to rise off of the ground. The lift must be greater than the weight of the airplane for the airplane to be able to takeoff. Lift is a force and can be quantified using the following formula:

force = pressure x area

Theoretically, the amount of lift obtained from a wing should be proportional to the pressure and the wing area. In reality, the lift force is not exactly equal to the product of pressure and area. The portion of the force being transformed into lift is measured by the coefficient of lift (C_L). C_L is determined by dividing the measured lift by the dynamic pressure and the wing area. The value for C_L varies with the angle of attack. Angle of attack is measured between the airstream and an imaginary line between the leading and trailing edges of the wing. The graph shown below represents a typical curve of angle of attack versus coefficient of lift. This is called the lift curve.





Lift and Drag for 1903 Flyer: Comparison of Theory and Data

QUESTIONS

1. Why do you think C_L varies with the angle of attack?

2. For a pilot, what is the advantage of plotting lift of coefficient versus angle of attack?

3. The maximum value on the y-axis is called the C_{Lmax}. What information does this value provide?

4. At approximately 14° the graph turns downward. How would you explain this?

5. As the graph turns downward, the negative slope can be gentle or abrupt. How would expect the plane to react in each situation?

6. The y-intercept on this graph is .2 . Explain why the y-intercept is not 0.

7. When would you expect the y-intercept to be 0?

8. What is determined by the slope of the lift curve?

9. Between 0° and 14° , the lift curve is a straight line. What conclusion can be drawn from this?

10. For the graph given the C_L max is 1.4. Compare this wing with one that has a C_L max of 1.0. In preparation for the anniversary of the first flight of the Wright Brothers, the American Institute of Aeronautics and Astronautics (AIAA) has built a replica of the 1903 Wright Flyer. This replica will be tested in the wind tunnels at Ames Research Center. (Data available March/April 1999?) Two of the data sets collected are angle of attack (alpha on the data table) and coefficient of lift (C_L). Plot this data using angle of attack as the independent variable (x-axis) and C_L as the dependent variable (y-axis). You may create the plot manually, use computer, or a graphing calculator.

11. Compare and contrast your graph with the one pictured above. Explain the similarities and differences. Shown on the graph below are graphs generated from computer modeling and scale model testing. As part of the Wright Flyer Project, two member of the Wright Flyer Project, have calculated some of the major aerodynamic characteristic of the airplane. Using two different computer programs, James Howford and Stephen Dwyer have calculated load distributions, lift and pitching moment for the Flyer replica. Probably the best scientific work by the Wright Brothers is their wind tunnel testing. They used a small wind tunnel to validate some airfoil data obtained from other researchers, but systematic wind tunnel tests of their complete aircraft has never been found. To fill this gap in the data, two series of wind tunnel tests have been conducted through the AIAA Wright Flyer Project. The first used a 1/6 scale model built of wood and fabric, with steel truss wires, very similar to the original airplane. The main goals of the test were to obtain data about the effectiveness of wing warping. The second set of the wind tunnels test used a 1/8 stainless steel model.

12. Why is the lift curve graph for the wood and fabric model different from the lift curve graph for the steel model?

13. Compare the graph you created from recent wind tunnel test data with the graph from the testing of the wood and fabric model. Explain the similarities and differences.

14. Compare the graph you created from recent wind tunnel test data with the graph from the testing of the steel. Explain the similarities and differences.

15. Compare the graph you created from recent wind tunnel test data with the graph from the computer model. Explain the similarities and differences.

16. Which model seems to provide the closest model for the actual Wright Flyer replica data? Support your conclusion.